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PLECOPTERA OF THE WEST FORK OF THE WEST GALLATIN RIVER
AND FACTORS INFLUENCING THEIR DISTRIBUTION

by

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A thesis submitted to the Graduate Faculty in partial
fulfillment of the requirements for the degree

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Head, Major Department

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VITA

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ABSTRACT

Factors affecting the distribution of Plecoptera in the West Fork of the West Gallatin River, Montana were investigated. From June, 1971 through July, 1972 benthos samples were taken using a Surber-type sampler at 10 stations. Another station was established in March, 1972 for an intensive study of insect-substrate relationships. Adult stoneflies were collected from February, 1972 through September, 1972. Differences in stream width, base flows, current velocity, substrate size composition, water temperature, bank canopy coverage, pH, total hardness, total alkalinity, ϕ -phosphate, nitrate, ammonia, periphyton and allochthonous detritus were noted at the 10 stations which were sampled monthly.

The most significant differences between sampling stations were found to be associated with the geology of the area and distribution of terrestrial vegetation. Major factors influencing the distribution of stoneflies in the West Fork study area were apparently substrate, food, stream width and temperature.

INTRODUCTION

The stoneflies (Plecoptera) of the West Fork of the West Gallatin River and some probable factors affecting their distribution were examined during a 15 month study beginning in July, 1971. The West Fork was chosen for this study because of the ingress of a recreational development into this semiprimitive area and baseline information about the fauna of this area was desired. The influence of the development on the West Fork in terms of changes in water quality due to sewage effluent, increased sediment load, or other factors could hopefully be monitored in the future via reactions of the stonefly species complex which should vary little from year to year under undisturbed conditions according to Hynes (1961).

Rather than doing a survey of the whole community of benthic fauna on the West Fork and using nebulous quantities, such as species diversity indices (Dickman, 1968; others), to indicate the relative stability of the communities present, a more intensive study of one taxocene, as suggested by Hurlbert (1971), was undertaken. This approach also avoids the necessity of trying to describe discrete communities at different sampling stations; this is generally impossible in such relatively unpolluted areas as noted by Armitage (1961). Since Wiggins (1964) has pointed out that the determination of the exact taxonomic composition of the fauna present is critical in such work, the choice of Plecoptera for the taxocene to be studied seems

to be justified. This order is relatively well known in this geographic area because of the works of Castle (1939), Gaufin, *et al.* (1966), Gaufin, *et al.* (1972) and Ricker (1943). Their papers were valuable aids in the identification of the species present.

Plecoptera also appeared to be a logical choice for the focus of a study such as this because of the relative sensitivity of the order to the types of changes in water quality expected to occur in the study area (Gaufin, 1965).

Presence of the taxa to be studied in the study area is of great importance when choosing a group for study. The West Fork could be classified as a torrential stream. Stoneflies are well adapted to this habitat according to such authors as Nielsen (1950, 1969) and Madsen (1968a). Specific factors influencing the distribution of this order in the rithron, as defined by Hynes (1970a), have been studied by many researchers. Hynes (1941b) noted many general characteristics of the ecology of the British Plecoptera. Minshall (1969) found that a large number of species were capable of being present in a stream despite a generally monotonous appearance of the stream. He also reported that stoneflies were a dominant taxa in headwater streams and Mackereth (1957) noted higher numbers of Plecoptera in swifter areas of a stony stream.

Due to the small altitudinal range of the study area, few problems associated with natural zonation were expected but it has

been pointed out by Minshall and Kuehne (1969) that Plecoptera are replaced as the dominant taxa as one proceeds downstream. Studies in the Rocky Mountains include that done by Dodds and Hisaw (1925) who showed a definite altitudinal zonation of Plecopteran species in Colorado. After a study of the Yellowstone River in Montana, Stadnyk (1971) concluded that downstream eutrophication was a major factor affecting the distribution of Plecoptera.

Mead (1971) makes a case for the use of simple models in ecological studies, and points out that even though two or more variables are known to be correlated, this should not prevent the analysis of their separate effects on a population. Therefore, in this study many interrelated variables were studied.

The importance of selecting similar sampling locations, as noted by Gaufin (1956), was kept in mind. Riffles, as defined by Keller (1971), were chosen for the primary areas of study. This was done because of the importance of turbulence, as noted by Eriksen (1964), in substrate-current-oxygen relationships. Ulfstrand (1967) has also pointed out the importance of the interplay of these three factors along with their effect on the distribution of food for benthic organisms. Thorup (1964) points out the biotopes and manifestations of other ecological variables are reflected by the substrate composition and Cummins (1964) has emphasized the importance of analyzing substrate size in studies of stream benthos. However, Scott (1964)

notes that all species do not react in the same way to changes in substrate composition.

It has been shown by Needham (1969) that production apparently varies with stream width, while the roles that aquatic and terrestrial primary producers play in community dynamics may also vary with stream size according to Chapman (1964). Minshall (1967) and Nelson and Scott (1962) have noted that allochthonous detritus may contribute from 50 to 100 percent of the energy to primary consumers.

Shading by riparian vegetation has been shown by Thorup (1970) to probably influence the frequency of benthos. Shading may strongly influence stream temperature and Minshall (1968) has noted an increase in variation of stream temperature with the lack of streamside vegetation. The distributions of two stonefly species have been shown to be closely tied to temperature by Minshall and Minshall (1966).

Temperatures low enough to produce consolidated sheet ice have been shown to kill benthic invertebrates by Brown, *et al.* (1953) while snow cover has been shown to be an effective insulator of streams by Gard (1963). Both conditions could be expected in the study area due to its location. However, some degree of cold may be necessary for the development of many Plecoptera, since Davis and Warren (1965) have shown high growth efficiencies for a stonefly in winter.

Temperature may influence the emergence patterns in insects according to Corbet (1964). Emergence complicates the study of the effects of environmental change on Plecoptera since the factors affecting life as an adult are not fully understood.

Life cycles are of primary importance and some knowledge of the life history of the insect becomes necessary when trying to understand factors influencing its distribution. This has been pointed out by Ulfstrand (1968b) who found apparent changes in the life cycles of a stonefly with changes in some environmental conditions.

Macan (1961b) has reviewed the literature on most of the above factors which are important in limiting the range of freshwater animals. In addition, he has pointed out the importance of certain chemicals. The importance of the effects of water chemistry to this study will be discussed later.

DESCRIPTION OF THE STUDY AREA

The study area is located about 50 kilometers (31 miles) due southwest of Bozeman, Montana on the West Fork of the West Gallatin River, which is a small east flowing tributary of the West Gallatin River (Figure 1).

The West Fork drains a structural and topographic basin bounded on the south and west by the Lone Mountain intrusive complex and on the north by the Pre-Cambrian Spanish Peaks (Montagne, 1971). Cretaceous strata form the exposed stratigraphic units of the basin and are interbedded with igneous sills. These overlay the Kootenai Formation, forming non-resistant units susceptible to various types of mass-gravity movements (Kehew, 1971).

The geology of the drainages of the tributaries to the West Fork has been described by Walsh (1971). The South Fork is characterized by muddy sandstone ledges and ribbon-like clay lenses below gravel surfaces. Located near Ousel Falls is the apex of an outwash consisting of Andesitic pebbles and cobbles. In terms of area drained, length of channel and sediment load, the South Fork is the largest of the tributaries to the West Fork. This drainage is the source area for West Fork plain outwash gravels and was probably extensively glaciated during the Bull Lake glaciation about 130,000 years ago (Dr. J. Montagne, personal communication).

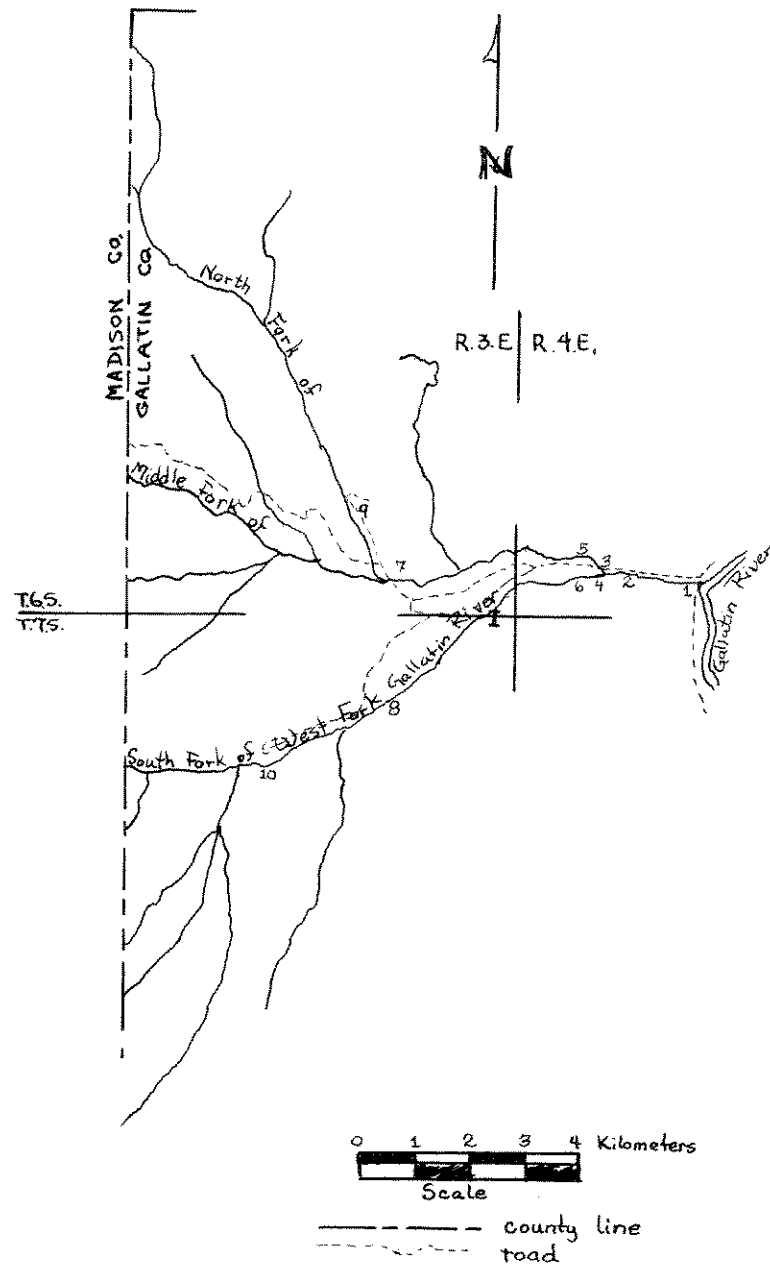


Figure 1. The West Fork of the West Gallatin River with Locations of Sampling Stations.

TABLE 1. THE LOCATION OF SAMPLING STATIONS.

Station	Elevation		Legal Description	Location
	Meters	(Feet)		
1	1830	(6000)	T6S, R4E:32	West Fork, immediately above Hiway U. S. 191 bridge.
2	1848	(6060)	T6S, R4E:32	West Fork, approx. 183 meters (200 yds.) below the confluence with the South Fork.
3	1853	(6075)	T6S, R4E:31	West Fork, immediately above its confluence with the South Fork.
4	1853	(6075)	T6S, R4E:31	South Fork, immediately above its confluence with the West Fork.
5	1860	(6100)	T6S, R4E:31	West Fork, below Big Sky meadow village.
6	1860	(6100)	T6S, R4E:31	South Fork, above major area of private homes.
7	1922	(6300)	T6S, R3E:35	West Fork, above the Big Sky meadow village.
8	1922	(6300)	T7S, R3E:2	South Fork, in a steep sided canyon.
9	1982	(6500)	T6S, R3E:35	North Fork, immediately below the Lone Mountain Guest Ranch.
10	1982	(6500)	T7S, R3E:10	South Fork, approx. 183 meters (200 yds.) above Ousel Falls.

Bull Lake moraines of the North Fork lie in the West Fork Basin near the confluence of the North and Middle Forks. The North Fork drainage is the only area of Pre-Cambrian outcrops and is separate from the bulk of the West Fork outwash.

The Middle Fork is more similar in geological aspect to the South Fork than the North Fork. No sampling stations for this study were established on the Middle Fork due to problems of accessibility at elevations around 1982 meters (6500 feet).

Stations 1 through 10 were established to check relative macrobenthos abundance, gather related data and collect adult Plecoptera. Their locations are shown on Figure 1 and Table 1. Another station, indicated by "I" on Figure 1, was established as an intensive sampling site in order to study benthic macrofauna-substrate relations. This station was located on the South Fork in T7S, R3E:1 at approximately 1891 meters (6200 feet) in elevation.

Major terrestrial vegetation types associated with the area are shown on the vegetation map (Figure 2, Montana State University, 1972).

When this study was undertaken, county and logging roads may have contributed some sediment to the stream during periods of runoff and some sewage effluent may have been entering the lower stretch of the stream from the few homes and ranches in the West Fork Basin.

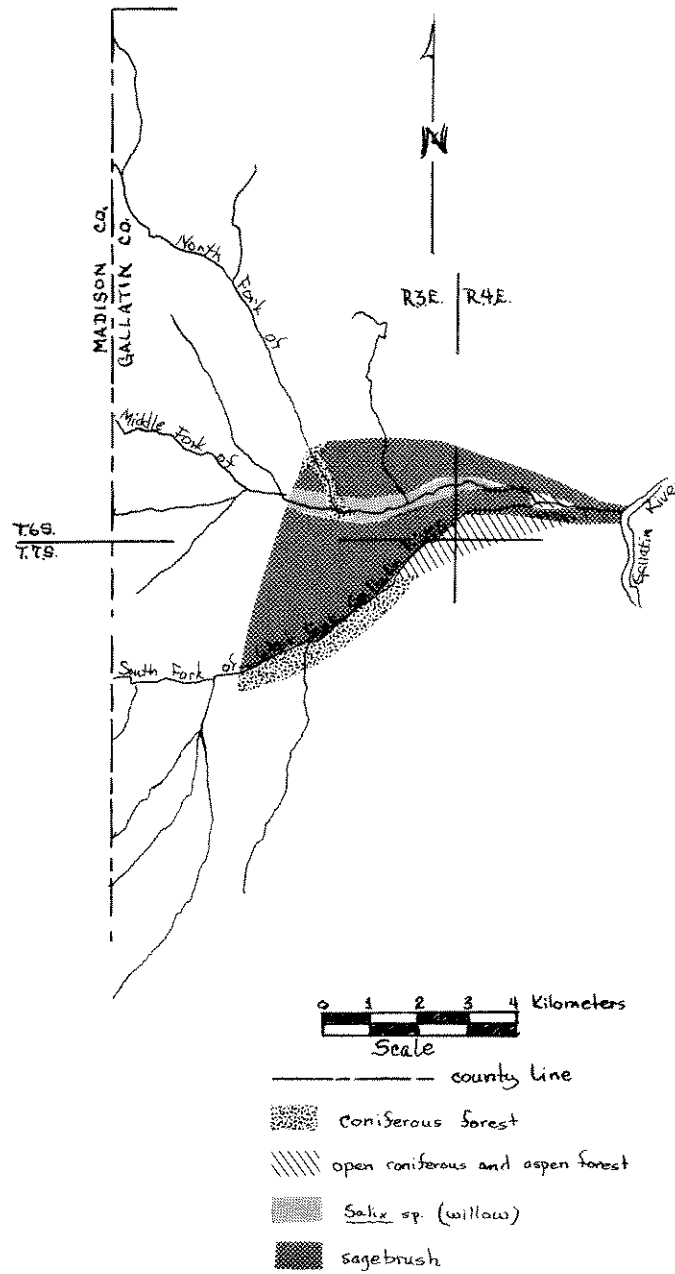


Figure 2. The Terrestrial Vegetation Associated with the Study Area (from Montana State University, 1972).

MATERIALS AND METHODS

Two types of benthos samples were taken; one set of samples was taken monthly and was used for the study of life histories and relative abundance of macroinvertebrates. A second set consisted of samples all collected on the same day and was used for the study of insect-substrate relationships.

Each month from July, 1971 through June, 1972 a composite sample was taken of the macrobenthos at each of stations 1 through 10. The composite sample consisted of two 0.1 m² samples taken with a square Surber-type sampler having a cod with 9 threads/cm and a pore size of approximately 1 mm². One 0.1 m² sample was taken near the center of the stream and the other was taken close to the edge of the stream. Water depth from which each sample was taken was recorded. Samples of benthos were taken only from substrate ranked as cobble or smaller by the Wentworth (1922) method. Due to the coarse nature of the substrate, samples were not taken deeper than 25 cm into the bottom. Although the work of Coleman and Hynes (1970) shows that many benthic invertebrates may live deeper, there is some question about whether or not loose substrate, such as they used in the traps, might induce deeper penetration into the bottom than would normally be found in a naturally compacted substrate. It is recognized that some inadequacy in the Surber-type sampler is inherent (Needham and Usinger, 1956); however, I deemed it a most desirable method after considering the

alternatives listed by Cummins (1962).

The second type of samples of benthos was taken in March, 1972 at the intensive sampling site. Ninety-six individual rocks along with the invertebrates associated with each rock were collected by placing a net behind each rock and lifting it from the substrate. The criteria used for selecting sampled rocks were as follows: first, each rock had to be 1 to 6 cm thick. Second, the current velocity over each rock had to be between .35 and .45 m/sec when measured with a Leupold-Stevens midget current meter. The following procedure was used in order to standardize measurements so that rock sizes could be compared. The area which approached being the greatest planar surface area of each rock was traced on paper and later measured in the laboratory. This area was used as a "rock surface area index" and was also used with thickness measurements to estimate actual rock surface area.

All benthos taken was preserved in the field with 40% formalin and later, in the laboratory, macroinvertebrates were separated from the debris by sorting after sugar flotation (Anderson, 1959) and preserved in 70% ethanol. These were later separated into various taxa and counted.

Adult Plecoptera were captured biweekly to monthly, depending on the intensity of emergence, from February, 1972 through September, 1972. At stations 1 through 10 the streamside vegetation was swept and rocks adjacent to the stream inspected during collecting periods.

Adults were preserved in 70% ethanol at the time of capture. These specimens were used to determine the taxa present and to study life histories.

In an attempt to relate the distribution of Plecoptera to various selected physical and chemical factors, quantitative values were collected for some of the habitat characteristics. In August, 1972 the average stream width was determined at each of stations 1 through 10 by taking 30 random measurements of the width of the water column, perpendicular to the main axis of stream flow. Estimates of base flows for the monthly sampling stations were secured from data published by Van Voast (1972) for March, 1970. Current velocity was measured during August, 1972 at each monthly sampling station. Four cross stream transects with 10 readings on each transect were made using the Gurly Pigmy current meter. The propeller was held about 5 cm above the substrate for all readings.

Substrate size composition was analyzed using a photographic method suggested by Cummins (1962). Two 35 mm photographs were taken at each of the monthly sampling sites using a glass-bottomed box. Slides of these photographs were projected to actual size on a 100 point grid in the laboratory. Percentage of coverage of the bottom in the boulder, cobble and pebble categories (classification after Cummins, 1962) was estimated by point intersections in each category. Determination of substrate composition via core samples and

determination of siltation rates with various collecting devices failed.

Water temperatures were taken monthly at all stations simultaneously with samples of benthos.

During August, 1972 the percentage of non-overlapping canopy coverage contributed by plants over 3 m in height along the banks of stations 1 through 10 was determined. The line intercept technique for vegetation analysis as outlined by Cox (1967) was used. One transect 30.5 m long was run parallel to the high water mark and approximately 3 m away from the high water mark on both sides of each station.

Dissolved oxygen was assumed to be minimally at saturation because of the torrential nature of the stream. This was borne out by the fact that all oxygen samples taken during August, 1971 showed supersaturation.

Summer (June, 1972-September, 1972) mean values for pH, total hardness, total alkalinity, ϕ -phosphate, nitrate and ammonia were obtained from the Department of Botany and Microbiology at Montana State University (unpublished data from NSF study, The Impact of a Large Recreational Development Upon a Semi-Primitive Environment).

Some qualitative observations were made on possible food sources for herbivorous benthos. The work of Smith (1950) was used in the identification of the major constituents of the periphyton, and

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relative amounts of allochthonous detritus were noted at stations
1 through 10.

RESULTS

Benthos

Tables 2 through 11 contain the data referring to nymphal Plecoptera collected at stations 1 through 10. Data concerning the other benthic macrofauna collected can be found in Tables 12 through 21, Appendix.

March and April data are singled out for most intensive study since winter growth had given most stonefly nymphs maximum size before emergence (Hynes, 1970b), most species had not emerged, and stream flows were minimal (Van Voast, 1972) making samples of benthos most accurate. It may be noted that the total number of macroinvertebrates was greater at station 5 than at any other station; however, the species composition was apparently comparable to station 7. Station 1 also had fairly large numbers of macroinvertebrates. Plecoptera represented the greatest percentage of numbers of collected macrofauna at station 3. This station was cleared of silt and slash by bulldozing of the channel between October and November sampling dates in 1971. Observed members of the recovery macrofauna were primarily *Nemoura* spp. and *Brachyptera nigripennis*. With the beginning of the snow melt in May, 1972 a drastic reduction in numbers of all invertebrates can be observed in the data from this station. Plecoptera represented the smallest proportion of the total collected macrofauna at station 10.

TABLE 2. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 1 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Pteronarcidae												
<i>Pteronarcys californica</i>				1(0)								
<i>Pteronarcys badia</i>	2(1)	3(1)	5(2)	7(2)	2(1)	4(1)	2(0)	4(1)				
Nemouridae												
<i>Nemoura cinctipes</i>			29(9)	19(5)	14	35(6)	12(2)	5(1)				
<i>Nemoura</i> spp.	2(1)	2(1)		1(0)	1(0)	123(22)	236(40)	242(40)	167(47)	1(1)		
<i>Brachyptera nigripennis</i>			14(4)	53(15)	34(11)	61(11)	58(10)	31(5)				
Perlodidae												
<i>Isogenus modestus</i>	3(3)	2(1)	2(1)	1(0)	3(1)		1(0)	2(0)	2(1)	2(3)		
<i>Arcynopteryx (Megarcys)</i>					1(0)	2(0)			2(1)			
Perlidae												
<i>Acroneuria pacifica</i>			1(0)	2(1)						1(1)		
Chloroperlidae												
<i>Paraperla frontalis</i>				5(1)	2(1)	4(1)			3(0)	1(0)		
<i>Alloperla</i> spp.	3(3)	8(3)	2(1)	5(2)	8(2)	4(1)	7(1)	1(0)	6(1)	5(1)	2(3)	1(1)
Unknown				1(0)			1(0)		1(0)	1(0)		3(3)
Total												
Plecoptera	6(6)	14(6)	10(4)	55(17)	99(28)	57(18)	238(42)	309(52)	294(48)	178(50)	6(8)	4(4)
Number Taxa	2	4	5	6	8	7	8	5	7	5	4	1
Total Benthos	93	253	253	321	359	320	572	592	611	354	71	108

TABLE 3. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 2 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Pteronarcidae												
<i>Pteronarcella badia</i>					2(1)		2(0)			1(1)		
Nemouridae												
<i>Nemoura cinctipes</i>				2(1)	15(7)		28(6)	2(1)	5(2)	2(1)		
<i>Nemoura</i> spp.		4(2)					78(16)	47(18)	44(20)	41(25)	6(9)	
<i>Brachyptera nigripennis</i>				8(4)	47(23)		142(29)	14(5)	7(3)			
Perlodidae												
<i>Isogenus modestus</i>	5(5)			1(0)	1(0)				1(0)			18
<i>Arcynopteryx (Megareys)</i>		2(1)	7(3)	7(4)			4(1)	1(0)	1(0)			
Perlidae												
<i>Acroneuria pacifica</i>							1(0)					
<i>Acroneuria theodora</i>			1(0)									
Chloroperlidae												
<i>Paraperla frontalis</i>			1(0)		1(0)		3(1)	3(1)		1(1)		
<i>Alloperla</i> spp.	1(1)	2(1)	5(2)	5(3)	4(2)		6(1)	7(3)	4(2)	3(2)	1(2)	
Unknown					2(1)				2(1)	2(1)	1(2)	4(4)
Total												
Plecoptera	6(6)	8(4)	14(6)	23(12)	72(35)		264(54)	74(28)	64(29)	50(31)	8(12)	4(4)
Number Taxa	2	3	4	5	6		8	6	6	5	2	0
Total Benthos	99	205	232	192	207		485	261	220	163	66	113

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TABLE 4. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 3 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Nemouridae												
<i>Nemoura</i>												
<i>cinetipes</i>				10(5)	1(2)		5(2)	4(1)	1(0)	4(1)		
<i>Nemoura</i> spp.			1(0)	9(5)			113(53)	118(26)	89(44)	306(68)		1(3)
<i>Brachyptera</i>												
<i>nigripennis</i>				4(2)	10(15)		18(8)	194(42)	41(20)	8(2)		
<i>Capnia</i> spp.							1(0)					
Perlodidae												
<i>Arcynopteryx</i>												
(<i>Megarctys</i>)			2(1)	1(0)								
Chloroperlidae												
<i>Paraperla</i>												
<i>frontalis</i>		1(0)	1(0)				2(1)		3(2)	4(1)		
<i>Alloperla</i> spp.		1(0)	6(2)	1(0)			4(2)	5(1)	7(4)	10(2)		1(3)
Unknown								1(0)		1(0)		
Total												
Plecoptera	0(0)	2(1)	10(4)	25(13)	11(17)		143(67)	322(70)	141(70)	333(74)	0(0)	2(6)
Number of Taxa	0	2	4	5	2		6	4	5	5	0	2
Total Benthos	107	270	237	193	65		212	459	200	450	9	34

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TABLE 5. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 4 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
<i>Pteronarcidae</i>												
<i>Pteronarcella</i>				1(0)					1(0)			
<i>badia</i>												
<i>Nemouridae</i>												
<i>Nemoura</i>												
<i>cinatipes</i>			3(2)	7(4)	12(4)				2(1)	3(1)		
<i>Nemoura</i> spp.	1(1)								71(25)	77(32)	15(13)	
<i>Brachyptera</i>												
<i>nigripennis</i>				30(16)	78(27)				36(13)	29(12)		
<i>Capnia</i> spp.					7(2)				5(2)	5(2)		
<i>Perlodidae</i>												
<i>Diura</i>						ICE COVER						
<i>knowltoni</i>							ICE COVER				1(1)	
<i>Arcynopteryx</i>												
(<i>Megarctys</i>)	1(1)	2(3)	4(2)		4(1)				2(1)	2(1)	1(1)	
<i>Chloroperlidae</i>												
<i>Paraperla</i>												
<i>frontalis</i>		1(1)	1(1)	1(0)	4(1)				8(3)	3(1)	2(2)	
<i>Alloperla</i> spp.		1(1)	2(1)	5(3)	10(3)				30(11)	10(4)	7(6)	
Unknown					2(1)					2(1)	1(1)	
Total												
Plecoptera	2(3)	4(5)	10(6)	44(24)	117(40)				155(55)	131(55)	27(23)	0(0)
Number Taxa	2	3	4	5	6				8	7	5	0
Total Benthos	72	75	159	185	290				282	238	119	66

TABLE 6. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 5 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Nemouridae												
<i>Nemoura cinctipes</i>			5(1)	7(2)	8(2)	15(3)	6(1)	13(2)	16(3)	4(1)		
<i>Nemoura</i> spp.		4(1)	25(5)	23(5)			114(14)	215(39)	137(24)	311(52)		3(1)
<i>Brachyptera nigripennis</i>			4(1)	82(26)	113(25)	11(1)	43(8)	7(1)	2(0)	4(1)		
<i>Brachyptera</i> spp.										1(0)		
<i>Capnia</i> spp.												1(0)
Perlodidae												
<i>Diura knowltoni</i>	2(1)		1(0)									
<i>Arcynopteryx</i> (<i>Megareys</i>)			2(0)	1(0)	1(0)	1(0)	1(0)	1(0)	2(0)	1(0)		
Perlidae												
<i>Acroneuria pacifica</i>											1(1)	
Chloroperlidae												
<i>Kathroperla perditia</i>			1(0)			1(0)			1(0)			
<i>Paraperla frontalis</i>		1(0)	5(1)	3(1)		9(2)	3(0)		7(1)	5(1)		
<i>Alloperla</i> spp.			20(4)	8(2)	37(12)	35(8)	7(1)	4(1)	15(3)	10(2)	7(7)	1(0)
Unknown	1(1)					2(0)	2(0)	2(0)		3(0)		1(0)
Total												
Plecoptera	3(2)	5(1)	59(12)	46(10)	128(40)	176(40)	144(17)	278(51)	187(32)	339(57)	8(8)	6(3)
Number Taxa	2	2	7	6	4	6	6	5	8	7	2	3
Total Benthos	172	479	484	441	321	446	826	547	577	592	109	215

TABLE 7. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 6 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Nemouridae												
<i>Nemoura</i>												
<i>cinetipes</i>			1 (1)	2 (2)	2 (1)		9 (4)		4 (2)	2 (1)		
<i>Nemoura</i> spp.	7 (8)					13 (12)	87 (39)		31 (18)	35 (16)	1 (1)	
<i>Brachyptera</i>												
<i>nigripennis</i>			8 (7)	11 (10)	44 (30)	21 (19)	32 (14)		15 (8)	20 (9)		
<i>Capnia</i> spp.						1 (1)	1 (0)					
Perlodidae												
<i>Isogenus</i>	1 (1)	1 (1)										
<i>modestus</i>												
<i>Diura</i>												
<i>knowltoni</i>	1 (1)											
<i>Arcynopteryx</i>												
(<i>Megareys</i>)	4 (4)	2 (2)	2 (2)	1 (1)	1 (1)	5 (5)			4 (2)	2 (1)	1 (1)	2 (3)
Chloroperlidae												
<i>Paraperla</i>												
<i>frontalis</i>	1 (2)	1 (1)			1 (1)				4 (2)	7 (3)		1 (1)
<i>Alloperla</i> spp.	3 (3)	2 (2)	5 (5)	4 (3)			7 (3)		20 (11)	27 (12)	3 (4)	5 (7)
Unknown	1 (2)		1 (1)				6 (3)		3 (2)	1 (0)	2 (3)	4 (5)
Total	2 (3)	17 (19)	15 (13)	20 (19)	52 (36)	40 (37)	142 (64)		81 (46)	94 (42)	7 (10)	12 (16)
Plecoptera	1	6	5	4	5	4	5		6	6	3	3
Number Taxa	66	88	117	106	144	108	221		177	226	69	76
Total Benthos												

TABLE 8. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 7 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
<hr/>												
Nemouridae												
<i>Nemoura</i>												
<i>cinatipes</i>				12 (8)	11 (7)	5 (2)	8 (2)		8 (2)			
<i>Nemoura</i> spp.		8 (5)	41 (22)				5 (1)		7 (2)	40 (15)	4 (7)	
<i>Brachyptera</i>				4 (3)	38 (24)	62 (21)	214 (41)		91 (28)	34 (13)		
<i>nigripennis</i>						2 (1)	2 (0)		7 (2)	4 (2)		
<i>Brachyptera</i> spp.				1 (1)			4 (1)					
<i>Capnia</i> spp.												
Perlodidae												
<i>Diura</i>												
<i>knowltoni</i>							2 (0)					
<i>Arcynopteryx</i>												
(<i>Megarays</i>)	1 (1)	1 (0)	5 (3)	3 (2)	1 (1)		14 (3)		1 (0)	1 (0)	2 (3)	1 (2)
Chloroperlidae												
<i>Kathroperla</i>												
<i>perdita</i>					1 (1)							
<i>Paraperla</i>												
<i>frontalis</i>			1 (0)				4 (1)					
<i>Alloperla</i> spp.			4 (2)	1 (1)		2 (1)						
Unknown	1 (1)		2 (1)			1 (0)	3 (1)		2 (1)	2 (1)		2 (4)
Total												
Plecoptera	2 (3)	9 (6)	53 (28)	21 (15)	51 (32)	72 (25)	256 (49)		116 (36)	81 (31)	6 (10)	3 (7)
Number Taxa	1	2	4	5	4	4	8		5	4	2	1
Total Benthos	78	157	188	144	160	290	521		321	260	59	44

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TABLE 9. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 8 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Nemouridae												
<i>Nemoura</i>												
<i>cinctipes</i>				6 (5)	2 (2)				3 (1)	4 (3)	10 (10)	
<i>Nemoura</i> spp.	1 (2)	2 (4)	2 (2)						28 (9)	32 (23)	3 (3)	
<i>Brachyptera</i>												
<i>nigripennis</i>				9 (7)	50 (41)				59 (20)			
<i>Capnia</i> spp.					1 (1)							
Perlodidae												
<i>Isogenus</i>												
<i>modestus</i>	2 (3)											
<i>Diura</i>												
<i>knowltoni</i>	1 (2)									1 (1)		
<i>Arcynopteryx</i>												
(<i>Megarcys</i>)	5 (8)		2 (2)	1 (1)	1 (1)				6 (2)	3 (2)	1 (1)	
Chloroperlidae												
<i>Alloperla</i> spp.		4 (8)	3 (2)	3 (2)						4 (3)	2 (2)	
Unknown			1 (1)	4 (3)	2 (2)				2 (1)	4 (3)		
Total												
Plecoptera	9 (15)	6 (11)	8 (6)	23 (18)	56 (46)				98 (33)	48 (34)	16 (17)	0 (0)
Number Taxa	4	2	3	4	4				3	5	4	0
Total Benthos	61	53	130	125	123				299	140	95	80

TABLE 10. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 9 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Peltoperlidae												
<i>Peltoperla mariana</i>												1(1)
<i>Peltoperla brevis</i>			2(1)	1(0)	1(0)							
Nemouridae												
<i>Nemoura cinctipes</i>			55(28)	43(20)	44(14)	3(1)	9(3)		17(6)	3(2)	3(2)	
<i>Nemoura</i> spp.				1(0)			2(1)		31(10)	18(6)	8(6)	1(3)
<i>Brachyptera nigripennis</i>				63(29)	130(40)	130(44)	109(37)		70(24)	15(10)	2(0)	
<i>Capnia</i> spp.					1(0)	1(0)	8(3)		2(1)			
<i>Eucapnopsis brevicauda</i>			1(0)		1(0)	1(0)				1(1)		
Perlodidae												
<i>Diura knowltoni</i>					1(0)		1(0)			1(1)		
<i>Arcynopteryx</i> (Megarcys)	1(1)	7(5)	8(4)	4(2)	8(2)	8(3)	1(0)		5(2)	7(4)	6(4)	
Perlidae												
<i>Acroneuria theodora</i>			1(1)							1(1)		
Chloroperlidae												
<i>Kathroperla perditia</i>			1(1)		1(0)	1(0)						
<i>Paraperla frontalis</i>				1(0)	6(2)		1(0)					
<i>Alloperla</i> spp.		1(1)		2(1)	1(0)		4(1)		1(0)			3(8)

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TABLE 10. (Continued)

	July	A	S	O	N	D	J	F	M	A	M	June
Unknown					1(0)	1(0)				3(2)		
Total												
Plecoptera	1(1)	27	(18)66	(34)115	(54)195	(61)145	(49)135	(46)	126(43)	49(31)	20(14)	4(10)
Number Taxa	1	5	4	7	10	6	8		6	7	5	2
Total Benthos	95	146	196	214	321	298	291		294	157	143	38

TABLE 11. NUMBERS OF PLECOPTERAN NYMPHS COLLECTED AT STATION 10 (NUMBERS IN PARENTHESES INDICATE THE NEAREST WHOLE PERCENTAGE OF THE TOTAL NUMBERS OF BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Nemouridae												
<i>Nemoura</i>												
<i>cinetipes</i>		10 (8)	20 (12)	10 (4)	2 (1)				4 (2)	20 (9)	3 (4)	2 (2)
<i>Nemoura</i> spp.												
<i>Brachyptera</i>												
<i>nigripennis</i>			3 (2)	127 (45)	110 (31)				6 (3)	15 (7)	1 (1)	
<i>Brachyptera</i> spp.											1 (1)	
<i>Capnia</i> spp.										6 (3)		
Perlodidae												
<i>Arcynopteryx</i>												
(<i>Megarcys</i>)	2 (2)	1 (1)	3 (2)	1 (0)	6 (2)	ICE COVER	ICE COVER	ICE COVER	1 (0)			2 (2)
Chloroperlidae												
<i>Alloperla</i> spp.	1 (1)		1 (1)	3 (1)	2 (1)				6 (3)	3 (1)	2 (3)	2 (2)
Unknown									2 (1)		1 (1)	
Total												
Plecoptera	3 (4)	11 (9)	27 (16)	141 (50)	120 (34)				19 (8)	44 (19)	8 (11)	6 (4)
Number Taxa	2	2	4	4	4				4	4	4	3
Total Benthos	79	124	169	285	353				224	229	72	132

When the total number of Plecopteran taxa taken as nymphs which were observed at each monthly sampling station during the sampling year are studied (Figure 3), it may be seen that the greatest number occurred on the North Fork, while the South Fork had consistently fewer taxa than the West and North Forks at comparable elevations. The only exception occurred at station 3, the bulldozed station, which was observed to have as few taxa as any of the other stations.

The suborder Filopalpia is shown as a percentage of the total numbers of Plecoptera in Figure 4 (March and April, 1972 averages). It is apparent that Filopalpia makes up a greater proportion of the Plecoptera at station 5, on the West Fork, than on the South Fork at the same elevation.

The most common family of Plecoptera was Nemouridae. *Nemoura cinctipes*, other *Nemoura* spp., and *Brachyptera nigripennis* were abundant at stations 1 through 10. Members of the genus *Capnia* were taken at all stations, except 1 and 2 on the main West Fork; however, station 4 was the only station where they were reasonably common. *Eucapnopsis brevicauda* was rare and was found only at station 9.

Members of the family Chloroperlidae were second in abundance, with *Alloperla* spp. being common at all ten of the stations sampled monthly. *Paraperla frontalis* was collected at all stations except 8 and 10 on the South Fork. At stations 5, 7 and 9 on the West and North Forks a few *Kathroperla perdita* were collected.

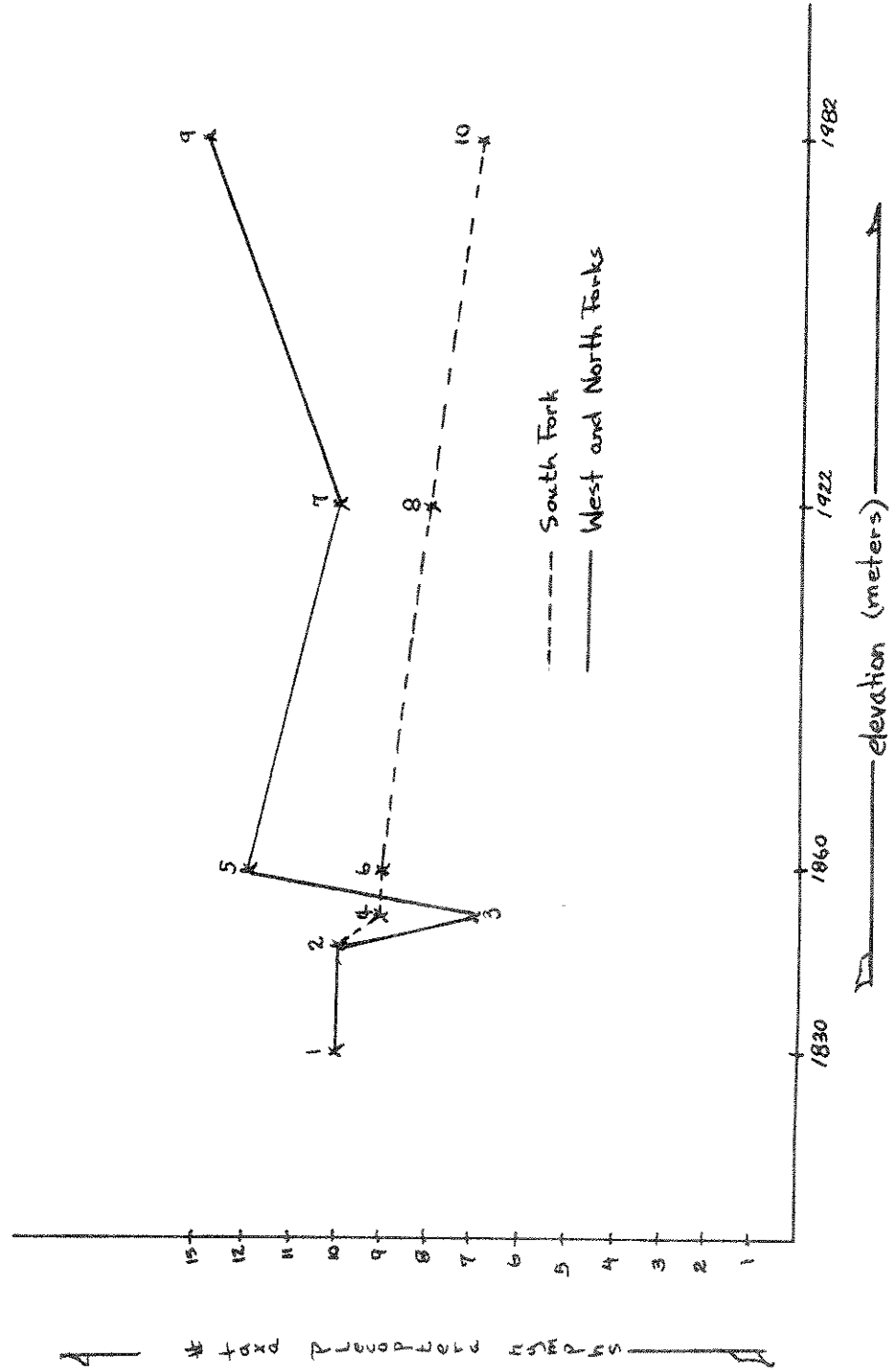


Figure 3. The Total Number of Taxa of Nymphal Plecoptera Collected at each Station.

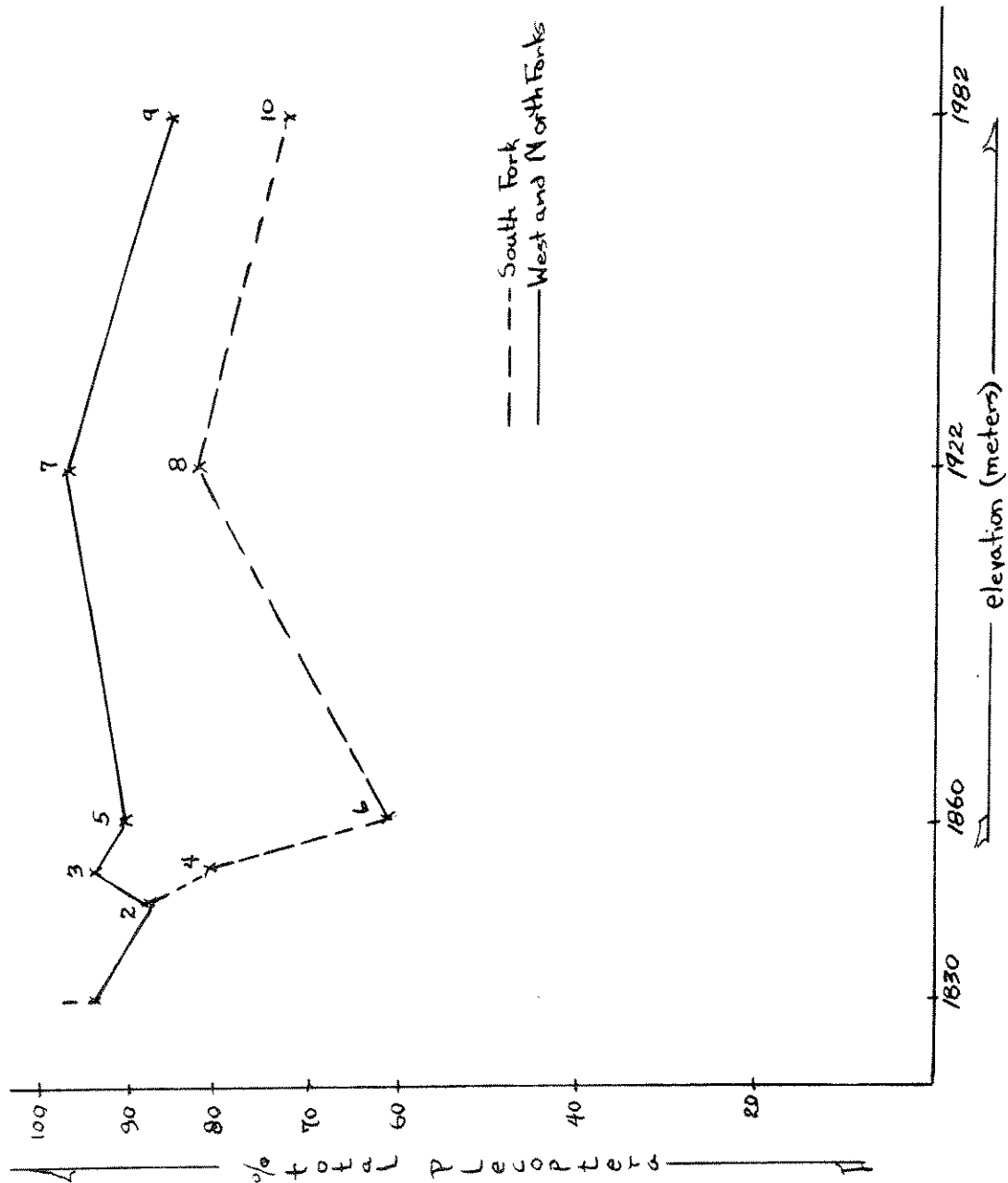


Figure 4. Filopalpia, as a Percentage of the Total Nymphal Plecoptera, Collected at each Station.

The chief representative of the Perlodidae was *Arcynopteryx* (*Megarocys*) spp., which was universally present but not abundant at any station. *Isogenus modestus* was fairly common in samples from stations 1 and 2, and present up the South Fork (stations 6, 8 and 10), while *Diura knowltoni* was present at stations 4, 5, 6, 7, 8 and 9.

Perlidae was present as *Acroneuria pacifica* at stations 1, 2 and 5 with *A. theodora* being found at stations 2 and 9. Both species were rare.

Pteronarcella badia was common at station 1, present at station 2 and rarely taken at station 4. The only other member of the Pteronarcidae found in the West Fork was *Pteronarcys californica* which was represented by one individual collected at station 1.

Two species of Peltoperlidae were taken in the West Fork, both at station 9. *Peltoperla brevis* was more common, while *P. mariana* was rare.

Data from the intensive sampling site is presented in Figure 5. The relationship between the numbers of macroinvertebrates and the surface area of the rock with which they were associated is apparently linear. The correlation coefficient for the data presented is .88 and significant at the 1.0 percent level (Snedecor and Cochran, 1967). The only individual species of Plecoptera which was present on enough rocks to allow the use of a regression analysis to compare rock surface area and numbers of Plecoptera was *Brachyptera nigripennis*. The data for

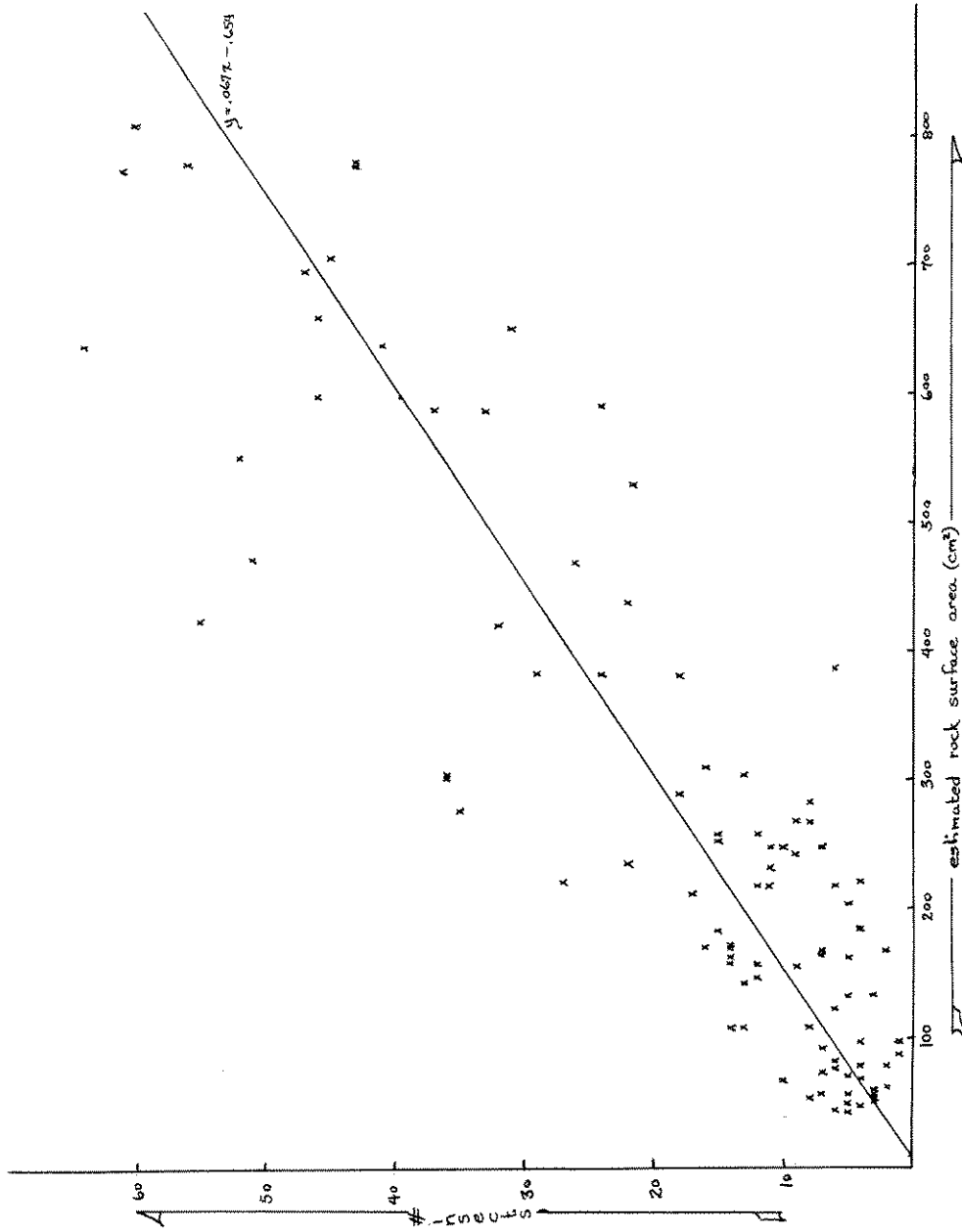


Figure 5. Density Regression: The Numbers of Insects Associated with a Rock vs. the Estimated Surface Area.

this species shows essentially the same relationship as the data presented in Figure 5, probably because *B. nigripennis* was the major constituent of the sampled benthos.

In an effort to predict the numbers of invertebrates expected from a composite sample the formula: $t = 0.176 s + 2.30$, comparing "rock surface area index" (s) to the number of insects associated with these rocks (t), was used. The data which generated this linear equation had a correlation coefficient of .84 and was significant at the 1.0 percent level. Photographic slides of substrate for each of stations 1 through 10 were analyzed and these results, coupled with the formula, were used in estimating total benthic macroinvertebrates expected at each station. Estimates were very high when compared to actual March collection data.

Adults

The altitudinal distribution of adult stonefly species captured is shown in Figure 6.

Capnia coloradensis was the earliest stonefly to be captured as an adult. Individuals of this species were captured from the third week in March, 1972 to the third week in April. *C. confusa* was only recorded to emerge in the third week of May. Other Nemouridae were also early emergents. Adults of both *Nemoura haysi* and *Brachyptera nigripennis* were noted during the third week in May, while *Nemoura cinctipes* and *N. besametsa* were seen as adults from the third week in

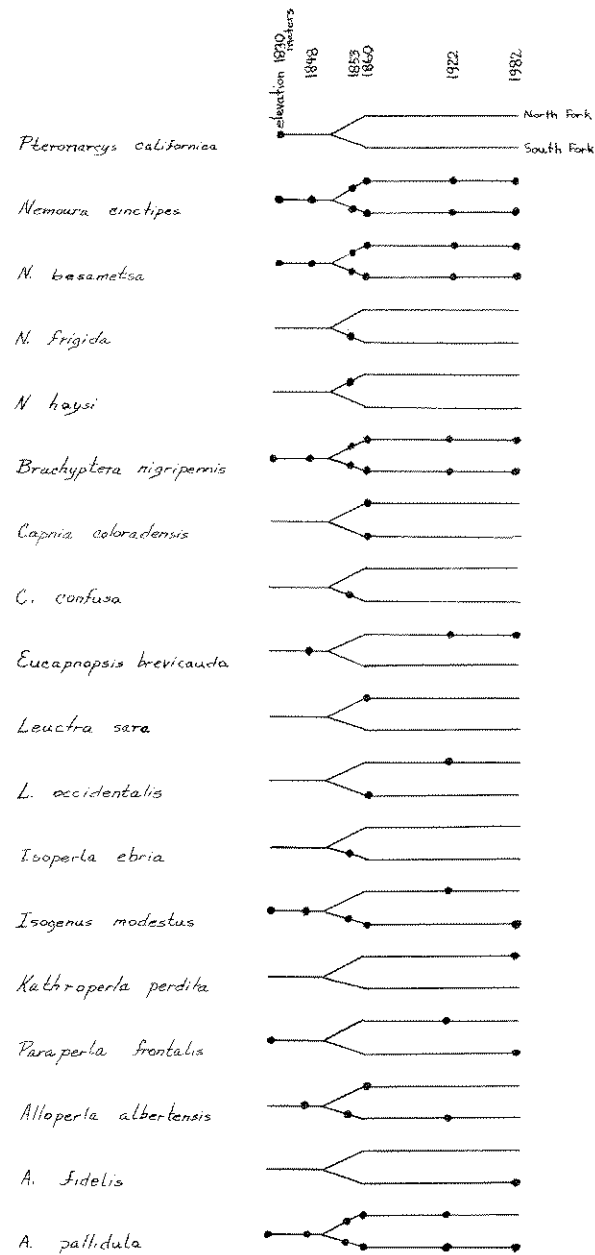


Figure 6. Schematic Representation of the Altitudinal Distribution of Adult Plecoptera (Dots represent presence).

May through the first week in August. *N. besametsa* was by far the most abundant adult stonefly captured. *Eucapnopsis brevicauda* was taken from the third week in May until the second week in June. *Leuctra occidentalis* was captured only during the third week in May, while *L. sara* was found only during the second week in June. *Nemoura frigida* was also collected during the second week in June.

Chloroperlidae started to be evident in samples during June. Both *Kathroperla perdita* and *Paraperla frontalis* were observed during the second week in June. *Alloperla albertensis* was taken from the second week in June until the last week in July, while *A. fidelis* was collected only during the last week in July. The second week in August *A. pallidula* was captured. It was noted that this latter species was found almost exclusively on willows bordering the sampling stations, and was one of the most abundant species of adult Plecoptera captured.

Isoperla ebria was represented by one individual captured during the second week in June. The other Perlodidae captured was *Isogenus modestus* which was found emerging on streamside rubble from the last week in July through the second week in August.

Only one individual of the Pteronarcidae was captured, this being a specimen of *Pteronarcys californica* which was taken during the last week in June.

Species Present

Based on analysis of both adults and nymphs the West Fork was determined to probably contain at least the following 25 Plecoptera in the study area (classification after Gaufin, *et al.*, 1972).

Suborder Filipalpia

I. Family Peltoperlidae

- A. *Peltoperla* (*Yoraperla*) *brevis*
- B. *Peltoperla* (*Yoraperla*) *mariana* Ricker

II. Family Nemouridae

Subfamily Nemourinae

- C. *Nemoura* (*Prostoia*) *besametsa* Ricker 1952
- D. *Nemoura* (*Zapada*) *cinctipes* Banks
- E. *Nemoura* (*Zapada*) *frigida* Claassen
- F. *Nemoura* (*Zapada*) *haysi* Ricker

Subfamily Leuctrinae

- G. *Leuctra* (*Paraleuctra*) *occidentalis* Banks
- H. *Leuctra* (*Paraleuctra*) *sara* (Claassen)

Subfamily Capniinae

- I. *Capnia* (*Capnia*) *confusa* Claassen
- J. *Capnia* (*Capnia*) *coloradensis* Claassen
- K. *Eucapnopsis* *brevicauda* (Claassen)

Subfamily Taeniopteryginae

- L. *Brachyptera (Taenionema) nigripennis* (Banks)

III. Family Pteronarcidae

- M. *Pteronarcella badia* Hagen

- N. *Pteronarcys (Pteronarcys) californica* Newport

Suborder Setipalpia

IV. Family Perlodidae

Subfamily Isogeninae

- O. *Arcynopteryx (Megarcys) spp.*

- P. *Isogenus (Kogotus) modestus* (Banks)

Subfamily Isoperlinae

- Q. *Isoperla ebria* (Hagen)

Subfamily Perlodinae

- R. *Diura (Dolkrila) knowltoni* (Frison)

V. Family Chloroperlidae

Subfamily Paraperlinae

- S. *Kathroperla perdita* Banks

- T. *Paraperla frontalis* (Banks)

Subfamily Chloroperlinae

- U. *Alloperla (Suwallia) pallidula* (Banks)

- V. *Alloperla (Sweltsa) albertensis* Needham and Claassen

- W. *Alloperla (Sweltsa) fidelis* Banks

VI. Family Perlidae

Subfamily Acroneurinae

X. *Acroneuria (Calineuria) theodora* Needham and Claassen

Y. *Acroneuria (Hesperoperla) pacifica* Banks

Environment

Table 22 contains the physical and chemical data collected as described in the section on materials and methods.

Stream width is about the same throughout the study area except on the North Fork where it is considerably narrower. Not only is the North Fork narrower, it also carries less water than any of the other streams studied. Van Voast (1972) points out that, although flows for the South Fork and the West Fork above its confluence with the South Fork are almost equal during base flow, during the year the South Fork contributes about 60 percent of the water to the main West Fork.

Perhaps the most important factor that the current velocity data indicates is that there is a great amount of variability in velocity at some stations while others show little variation. This can be seen by studying the standard deviations. In general, stations with a greater percentage of boulder in the substrate have greater variability in current velocity. Conversely, station 9 on the North Fork, which has a low standard deviation for current velocity data, is characterized by a greater percentage of pebble in the substrate.

TABLE 22. PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE SAMPLING STATIONS.

	Station									
	1	2	3	4	5	6	7	8	9	10
I. Physical Character										
A. Substrate (%)										
1.) Boulder (>256mm)	50	9	0	0	0	0	0	21	0	11
2.) Cobble (256-64mm)	23	21	52	48	75	57	45	45	29	56
3.) Pebble (64-16mm)	27	70	48	52	25	43	55	34	71	33
B. Average Stream Width (m)	10.5	10.0	9.8	12.1	12.2	11.4	10.3	9.9	3.4	10.4
C. Average Sample Depth (m)	0.28	0.26	0.24	0.23	0.25	0.21	0.21	0.22	0.16	0.25
D. (a) Mean Current Velocity (m/s)	0.53	0.49	0.49	0.56	0.49	0.39	0.39	0.47	0.54	0.37
(b) [std. dev.]	[±0.14][±0.10][±0.10][±0.10][±0.12][±0.10][±0.08][±0.14][±0.06][±0.19]									
E. Minimum Flow (m ³ /s)	0.34			0.18			0.17		0.06	
F. Temperature Range (°C)	<1-12	<1-10	<1-11	<1-11	<1-11	<1-11	<1-10	<1-9	<1-8	<1-10
G. Percent Bank Canopy Cover	2.5	44	3.5	6	4.5	5.5	14	93	10	83.5
II. Chemical Character										
A. pH	8.16				8.10	8.26	8.01		8.02	8.22
B. Total Hardness (ppm)	107.0				85.6	102.9	67.7		69.6	99.8
C. Total Alkalinity (me/l)	1.97				1.70	2.08	1.37		1.53	1.88
D. ϕ -Phosphate (ppm)	0.006				0.006	0.003	0.007		0.002	0.009
E. Nitrate (ppm)	0.006				0.020	0.001	0.011		0.021	0.007
F. Ammonia (ppm)	0.005				0.002	0.010	0.006		0.001	0.008

Water depths from which samples were taken did not vary greatly between stations.

No striking differences between stations are noted in temperature data. This ~~does~~^{may} not mean that no differences existed, but rather that temperatures were probably taken too infrequently for meaningful analysis. The fact that there may be a difference in temperature characteristics of the stations is brought out when the number of months when ice cover prevented sampling is noted. The South Fork was ice covered more often during sampling dates than the West Fork, especially at higher elevations. A general downstream decrease in icing was also noted.

If the percentage of bank canopy coverage is used as an index of station shading, it can be seen that stations 8 and 10 on the South Fork are shaded to the greatest degree. While there is some upstream increase in shading on the West and North Forks, it never approaches levels attained on the South Fork. Station 2 also had a relatively high incidence of shading.

Few chemical characteristics were deemed worthy of mention; however, the total hardness was generally greater on the South Fork and increased downstream.

Several striking features related to the abundance of periphyton were noted. Diatoms were major constituents of the periphyton at all ten monthly sampling stations. Stations 1, 2, 5 and 7 had heavy blooms

of *Hydrurus foetidus* in October through April, while stations 4 and 6 were dominated by blooms of *Spirogyra* spp. in September and October.

Allochthonous detritus generally increased downstream from almost none observable at station 10 on the South Fork and some small amounts at station 9 on the North Fork to almost two handfuls per composite sample at station 1 in March. Buildup of detritus started occurring after the spring runoff and generally peaked in March and April just before runoff. The only station which was an exception to this was station 3 where a second buildup of detritus started after the bulldozing of that station.

DISCUSSION

General trends and outstanding points observed in the results of this study will be discussed before going into some possible explanations for the distributions of species of stoneflies noted in the study area. Despite the widespread use of multiple regression analyses in studies such as this, none was considered appropriate here because data on all variables were not well enough related temporally and spatially (Mead, 1971).

Maximum numbers of macroinvertebrates were taken at station 5. These high numbers could be due to several factors. First, possible nutrient addition upstream from this station may have made production higher here. Armitage (1958) has noted that standing crop may indicate production levels. However, Hynes and Coleman (1968) have reviewed several works pointing out that using standing crop as an index of production may cause errors. Eutrophication to the point of pollution is not indicated for several reasons, the most striking of which was the blooms of *Hydrurus foetidus* which is a clean water species (Hynes, 1970a). The composition of insect species at station 5 was also comparable to other stations, such as 7, which had fewer numbers of benthic macroinvertebrates.

A second possible reason for the high numbers of macroinvertebrates observed at station 5 is the fact that the substrate may have been more conducive to a higher standing crop at this station. Fraser (1935) and

Granton and Fraser (1935) have shown that mixed sediments provide less interstitial space than sediments of optimum uniform size. Higher percentage of cobble in the substrate could have allowed greatest rock surface area and greatest interstitial space for colonization by invertebrates. This seems to be borne out by Wene and Wickliff (1940) who found more numbers of insects on cobble than on gravel. Pennak and Van Gerpen (1947) also found maximum numbers of insects on cobble when compared to gravel or coarser substrate, such as bedrock, while Cummins and Lauff (1969) showed definite selection, especially by a stonefly, for coarser sediments.

An effort was made to relate the number of insects present on a given rock size to the data collected in March for stations 1 through 10. No clear relationship could be established between the regression on density and actual numbers of insects taken in composite samples. This is possibly due to the effect of other variables at the stations and the gross nature of the assumptions made to gain estimates of numbers of invertebrates expected from a composite sample based on the regression data. I feel that if Surber samples had been taken at the intensive sampling site and a photographic substrate analysis done of this area, more reliable estimates could have been made. At least a better understanding of the relationship between actual numbers of insects associated with a given rock size and the number of insects collected with the Surber sampler could have been gained.

It is possible that *Brachyptera nigripennis* was a major constituent of the benthos sampled at the intensive sampling site because only surface rocks were sampled. *Brachyptera* spp. has been shown to prefer the current characteristics of rock surfaces by Madsen (1969). This reaction of *Brachyptera* spp. to current and its need for relatively high oxygen (Madsen, 1968b) may also explain why station 3 was recolonized rapidly by *B. nigripennis*. The crushing of the substrate by bulldozing would make the rock surface one of the most readily available habitats for the rapid recolonization which was observed. The population apparently attained normal levels by January, 1972. This is in keeping with Waters' (1964) study which showed fairly rapid recolonization of denuded areas, returning populations in those areas to normal levels.

Members of the genus *Nemoura* apparently recolonized station 3 by drift, possibly being forced into the area because of high population density upstream. This may also hold true for *Brachyptera nigripennis*. Both Dimond (1967) and Waters (1961, 1966) have shown drift to increase for certain species at high population levels.

The relatively great decrease in numbers of insects at station 3 with the advent of the runoff may be due to the increased current and the increased effect of scouring since Hynes (1970b) and Macan (1961a) have shown increased velocity to be important in dislodging insects. This could be accentuated because of instability of the stream bottom caused by channelization by bulldozing. Several works (Leopold, *et al.*,

1964; Leopold and Langbein, 1966) indicate that channelization altering the natural course of the stream should cause instability in the artificial configuration of the stream.

Stability of substrate may also play an important role in influencing the distribution of Plecoptera in the whole West Fork study area. The high number of taxa found at station 9 may be due to stability. Despite the fact that the substrate is composed of smaller sediments, the collected macrofauna is characterized by relatively high numbers of "non-nimble" organisms, such as Turbellaria, which may be diagnostic of stable environments according to Macan (1963). On the other hand, the upper elevations on the South Fork which had fewer taxa are characterized by much less stable geology, such as clay lenses, than the Pre-Cambrian geology of the North Fork. I feel that the geological instability combined with the harshness of the winter icing conditions on the South Fork override factors which should allow for more species diversity on this stream. Since greatest variation in current velocity was observed on the South Fork, more niches should be available for species to occupy (Hynes, 1970a).

The geology of the South Fork also lends itself to a water chemistry more suitable to the maintenance of a higher standing crop than on the North Fork if the relationships observed by Egglshaw and Morgan (1965) on Scottish Highland streams hold true. Higher standing crop was not observed.

Distribution of Plecoptera may also be greatly influenced by shading as it is tied to food sources. Herbivorous Filopalpia (Illies, 1965) may represent a smaller proportion of the numbers of Plecoptera at higher elevations on the South Fork because Hughes (1966) has shown that an increase in shading cuts down algal growth. This could prevent blooms of the magnitude observed at stations other than 8 and 10.

Heavy blooms of *Hydrurus foetidus* may help explain relatively high numbers of Filopalpia present at station 5 when compared to the South Fork at the same elevation. Filopalpia in relatively high numbers on the lower West Fork may also be associated with relative increase in availability of allochthonous detritus as a food source. Several works (Chapman and Demory, 1963; Egglisshaw, 1964; Gaufin and Richardson, 1971) have shown allochthonous detritus to be important as food for Filopalpia.

Temperature could be a major factor in influencing the distribution of Plecoptera in the West Fork. Shading and icing on the South Fork both indicate a lower temperature environment, compared to the West Fork which is probably warmer and varies more in temperature because of the decrease in bank-side vegetation. Macan (1958) has pointed out such relationships.

Spring data for several of the stations seems to be in close agreement with Morgan and Egglisshaw's (1965) observations on Scottish Highland streams which showed an insect fauna comprised of 33 percent Plecoptera when numbers were considered. Data for each of the stations

also agree with Hynes (1970a) who shows about 10 species of Plecoptera inhabit stations where average stream temperatures in summer are 13-20° C. A total of 25 species from the West Fork study area as a whole seems high when compared to Knight and Gaufin's (1966) work which showed such high numbers of taxa only at elevations around 8000-9000 feet. This may be a function of differences in size of the studied streams or latitudinal differences.

More will be discussed about the apparent effect of stream size, as it is coupled with other variables, later, since Knight and Gaufin (1967) have pointed out tendencies for various stoneflies to inhabit certain size streams.

Now an attempt will be made to describe the factors apparently influencing the distribution of various species of Plecoptera encountered in the study area.

The genus *Peltoperla* is apparently limited to the North Fork. Garrett (unpublished data) also found *P. brevis* and *P. mariana* exclusively in the North Fork during his survey of the benthos of this drainage. The reasons for this limitation on the distribution of *Peltoperla* spp. are not wholly clear but may be coupled to stream stability or stream size. Other records of *Peltoperla* spp. in Montana (Gaufin, *et al.*, 1972) are also associated primarily with small streams.

Members of the genus *Nemoura* are quite common throughout the West Fork study area. *N. besametsa* and *N. cinctipes* were found at all

stations in the study area. This is not surprising due to the widespread nature of their recorded occurrence. *N. frigida* and *N. haysi* were too rare to allow for extrapolation of a meaningful distribution. A factor which complicated determination of the distribution of this genus in the West Fork is that *N. besametsa* was indistinguishable from *N. frigida* and *N. haysi* as a nymph.

Leuctra spp. were only collected as adults and then only rarely; therefore, the occurrence of this genus in the West Fork study area could be open to some question. They could have been blown into the area from the adjacent West Gallatin River or flown upstream, or they could have been blown downstream from upstream populations (Hynes, 1970b).

Capnia spp. were apparently widely distributed in the West Fork but may not have been detected at some stations because of the small size of members of this genus. No nymphs were evident in summer collections, probably because of diapause of either eggs or nymphs which Harper and Hynes (1970) indicate for some winter stoneflies.

The nature of the distribution of *Eucapnopsis brevicauda* is in some doubt due to its rare presence in collections; however, it is apparently limited to the West and North Forks. The most obvious reasons for this would be substrate stability and temperatures.

Brachyptera spp. were widely distributed in the study area and the peculiarities of the distribution of this genus were discussed earlier.

Pteronarcella badia may have been limited to the lower West Fork for one of two apparent reasons. First, this species might be limited to larger streams because of a propensity to deposit eggs in unsuitable places on smaller streams (Macan, 1961b), but this seems unlikely since stream width was not much different at most sampling stations. Second, the availability of detritus as a food source probably strongly influenced the distribution of this species. Since *P. badia* is a relatively large organism, the small amounts of detritus present at higher stations may have been insufficient to sustain a population large enough to sample, even though the species is somewhat omnivorous (Gaufin and Richardson, 1971).

The distribution of *Pteronarcys californica* is probably limited to the immediate vicinity of station 1 for much the same reasons as *Pteronarcella* spp. is limited in distribution. The food habits of the two genera are very similar (Gaufin and Richardson, 1971); however, stream size probably has more influence on the distribution of *Pteronarcys* spp. since it is so extremely rare in the West Fork and yet very common in the West Gallatin River (Garrett, unpublished data). Knight and Gaufin's (1964) work substantiate ruling out variables associated with oxygen as limiting factors because of the high oxygen concentrations in all of the streams in the study area.

The reasons for differences in the distribution of collected *Arcynopteryx* (*Megarcys*) spp., *Isogenus modestus* and *Diura knowltoni*

are not wholly clear but may be due to niche differences in relation to available food. Since all species were observed to be ravenously carnivorous, lower population levels of larger prey species at upper elevations may have allowed for competitive exclusion as suggested by Hynes (1941a) or Ulfstrand (1968a).

Isoperla ebria was collected only as a single adult. Its presence in the West Fork is open to question for the same reasons as were cited earlier for *Leuctra* spp.

No attempt will be made to explain the distributions of *Kathroperla* spp. and *Paraperla* spp. because of the sporadic nature of their occurrence, but *Paraperla* spp. was apparently distributed over the entire study area.

Of the *Alloperla* spp. only the occurrence of *A. pallidula* was recorded at all stations. The distributions of the other two species are uncertain since all members of the genus were indistinguishable from one another as nymphs.

The rare occurrence of *Acroneuria* spp. in the West Fork is apparently not greatly influenced by factors associated with oxygen (Knight and Gaufin, 1963) or suitable prey (Sheldon, 1969), but may be associated with stream size for much the same reasons as the distributions of other large stoneflies appear to be affected by stream size.

In general, the major factors influencing the distribution of Plecoptera in the West Fork study area seem to be substrate, food,

stream size and temperature.

Emergence patterns for all species fit into time periods published by Gaufin, *et al.* (1972), Radford and Rowe (1971), Sheldon and Jewett (1967), and Nebeker (1967). Data was insufficient to be more specific about life cycles and fit them into categories published by Corbet (1964) or Hynes (1961), nor was the data sufficient to ascertain the length of nymphal life as was done by such authors as Ulfstrand (1968b).

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APPENDIX

TABLE 12. NUMBERS OF MISC. BENTHOS FROM STATION 1 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Hydracarina							1 (0)	1 (0)		1 (0)		
Coleoptera												
Elmidae				1 (0)	1 (0)	1 (0)	2 (0)		2 (0)	2 (0)		
Diptera												
Blepharoceridae		2 (1)		3 (1)								
Tipulidae			2 (1)		1 (0)		2 (0)	1 (0)	1 (0)	1 (0)		
Simuliidae	2 (2)	12 (5)	13 (5)	18 (6)	15 (4)		17 (3)	11 (2)	16 (3)	7 (2)	4 (6)	9 (8)
Tendipedidae	6 (6)	121	119	135	130	178	213	210	232	95	12	10 (9)
		(48)	(47)	(42)	(36)	(56)	(37)	(35)	(38)	(27)	(17)	
Rhagionidae		4 (2)	5 (2)	9 (3)	8 (2)	3 (1)	4 (1)	2 (0)	1 (0)	3 (1)	2 (3)	
Tricoptera												
Hydropsychidae	5 (5)	17 (7)	13 (5)	24 (7)	30 (8)	20 (6)	25 (4)	10 (2)	13 (2)	8 (2)	9 (13)	9 (8)
Rhyacophilidae		1 (0)	2 (1)	7 (2)	12 (3)	7 (2)	4 (1)	9 (2)	2 (0)	4 (1)	1 (1)	4 (4)
Brachycentridae	1 (1)	4 (2)	1 (0)	2 (1)		1 (0)	3 (0)			2 (0)	2 (3)	2 (2)
Limnephilidae	4 (4)	4 (2)	1 (0)	2 (1)	1 (0)		8 (1)	4 (1)		2 (0)	1 (1)	
Ephemeroptera												
Ephemeridae	15 (16)	22 (9)	31 (12)	39 (12)	30 (8)	32 (10)	36 (6)	22 (4)	37 (6)	39 (11)	27 (38)	21 (19)
Baetidae	43 (46)	25 (10)	6 (2)	1 (0)	5 (1)	1 (0)		4 (1)	4 (1)	4 (1)	2 (3)	34 (31)
Heptageniidae	11 (12)	27 (11)	50 (20)	25 (8)	27 (7)	20 (6)	19 (3)	9 (2)	9 (1)	8 (2)	4 (6)	15 (14)
Nematoda											1 (1)	
Total	87	239	243	266	260	263	334	283	317	176	65	104
Individuals	(94)	(94)	(96)	(83)	(72)	(82)	(58)	(48)	(52)	(50)	(92)	(96)

TABLE 13. NUMBERS OF MISC. BENTHOS FROM STATION 2 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Turbellaria	1(0)											
Coleoptera												
Elmidae			1(0)				1(0)		2(1)	1(1)		
Diptera												
Blepharoceridae				1(0)								
Tipulidae		1(0)	1(0)	1(0)	3(1)				1(0)	2(1)		1(1)
Simuliidae		5(2)	4(2)	7(4)							1(2)	19(17)
Tendipedidae	6(6)	94(46)	88(38)	82(43)	32(15)		5(1)	7(3)	5(2)	9(6)	8(12)	3(3)
Rhagionidae		1(0)	6(2)		3(1)		4(1)	3(1)	2(1)	3(2)		4(4)
Tricriptera												
Hydropsychidae	2(2)	6(3)	44(19)	7(4)	18(9)		73(15)	24(9)	25(11)	12(7)	3(4)	6(5)
Rhyacophilidae		5(2)	3(1)	4(2)	3(1)		8(2)	38(14)	32(14)	12(7)	2(3)	2(2)
Brachycentridae	3(3)				1(0)		3(1)	1(0)	1(0)	2(1)	1(2)	
Limnephilidae	18(18)	16(8)	3(1)	2(1)	2(1)		2(0)	15(6)	12(5)	2(1)		1(1)
Ephemeroptera												
Ephemeridae	15(15)	21(10)	28(12)	45(24)	51(25)		61(12)	82(31)	63(29)	62(38)	16(24)	12(11)
Baetidae	26(26)	28(14)	28(12)	2(1)			2(0)	1(0)	1(0)	5(3)	7(11)	53(47)
Heptageniidae	23(23)	19(9)	12(5)	18(9)	22(11)		62(13)	16(6)	12(5)	3(2)	20(30)	8(7)
Total	93	197	218	169	135		221	187	156	113	58	109
Individuals	(94)	(96)	(94)	(88)	(65)		(46)	(72)	(71)	(69)	(88)	(96)

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TABLE 14. NUMBERS OF MISC. BENTHOS FROM STATION 3 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Coleoptera												
Elmidae		12(4)	4(2)	2(1)			1(0)		1(0)	2(0)		
Diptera												
Blepharoceridae			2(1)									
Tipulidae	2(2)	1(0)	1(0)	1(0)					1(0)	1(0)	3(33)	
Simuliidae		15(6)						2(0)		1(0)		
Tendipedidae	5(5)	122(45)	12(5)	14(7)			27(13)	10(2)		19(4)		
Rhagionidae								1(0)				
Tricoptera												
Hydropsychidae	4(4)	11(4)	9(4)	8(4)	3(5)		1(0)		1(0)			
Rhyacophilidae	1(1)	6(2)	17(7)	13(7)	4(6)		4(2)	82(18)	8(4)	27(6)		
Brachycentridae	1(1)	5(2)	4(2)						1(0)			
Limnephilidae	23(21)	43(16)	45(19)	24(12)			1(0)		2(1)	4(1)		1(3)
Ephemeroptera												
Ephemeridae	34(32)	14(5)	51(22)	57(30)	16(25)		6(3)	18(4)	14(7)	8(2)	2(22)	8(24)
Baetidae	28(26)	29(11)	18(8)	1(0)	2(3)		14(7)	15(3)	6(3)	10(2)		15(62)
Heptageniidae	9(8)	10(4)	64(27)	48(25)	29(45)		15(7)	9(2)	25(14)	45(10)	4(44)	8(24)
Total	107	268	227	168	54		69	137	59	117	9	32
Individuals	(100)	(99)	(96)	(87)	(83)		(32)	(30)	(30)	(26)	(100)	(94)

TABLE 15. NUMBERS OF MISC. BENTHOS FROM STATION 4 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Coleoptera												
Elmidae	1(1)											
Diptera												
Blepharoceridae									1(0)			
Tipulidae	1(1)	1(1)	1(1)	2(1)	1(0)				2(1)	2(1)		
Simuliidae	1(1)	5(7)	6(4)	2(1)	10(3)				3(1)	3(2)		3(4)
Tendipedidae		4(5)	1(1)	4(2)					6(2)	10(4)	52(44)	2(3)
Rhagionidae			3(2)	1(0)	2(1)				1(0)	4(2)		
Tricoptera												
Hydropsychidae		3(4)	5(3)	34(18)	49(17)				23(8)	8(3)	4(3)	1(2)
Rhyacophilidae		2(3)	5(3)	2(1)	2(1)				3(1)	1(0)	1(1)	
Brachycentridae	1(1)	1(1)	3(2)	1(0)	1(0)							
Limnephilidae		3(4)	2(1)		4(1)				2(1)	1(0)		
Ephemeroptera												
Ephemeridae	12(17)	5(7)	29(18)	23(12)	32(11)				21(7)	23(10)	11(9)	7(11)
Baetidae	36(50)	11(15)	9(6)	1(0)					3(1)	6(2)	6(5)	20(30)
Heptageniidae	18(25)	36(48)	58(36)	71(38)	72(25)				65(23)	49(20)	15(13)	33(50)
Total	70	71	149	141	173				127	107	92	66
Individuals	(97)	(95)	(94)	(76)	(60)				(45)	(45)	(77)	(100)

TABLE 16. NUMBERS OF MISC. BENTHOS FROM STATION 5 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Turbellaria								1 (0)				1 (0)
Coleoptera												
Elmidae		1 (0)	1 (0)	4 (1)	6 (1)			1 (0)	1 (0)	1 (0)		
Diptera												
Tipulidae	3 (2)	2 (0)		3 (1)		3 (1)				2 (0)	1 (1)	
Simuliidae		31 (6)	28 (6)	8 (2)						8 (1)		62 (29)
Tendipedidae	30 (17)	245 (51)	219 (45)	192 (44)	21 (6)	78 (18)	243 (29)	26 (5)	72 (12)	12 (2)		17 (8)
Rhagionidae			1 (0)									
Tricoptera												
Hydropsychidae		3 (1)	12 (2)	10 (2)	8 (2)	4 (1)	14 (2)	57 (10)	12 (2)	3 (0)	18 (18)	
Rhyacophilidae	8 (5)	16 (3)	26 (5)	27 (6)	31 (10)	35 (8)	321 (39)	68 (12)	213 (37)	126 (21)	16 (16)	7 (3)
Brachycentridae		1 (0)	8 (2)	3 (1)	4 (1)	4 (1)	4 (0)			9 (2)	1 (1)	
Limnephilidae	5 (3)	37 (8)	25 (5)	9 (2)	10 (3)	11 (2)	12 (1)	13 (2)	12 (2)	6 (1)	12 (12)	3 (1)
Ephemeroptera												
Ephemeridae	19 (11)	27 (6)	52 (11)	91 (21)	72 (22)	66 (15)	52 (6)	58 (11)	48 (8)	57 (10)	27 (26)	18 (8)
Baetidae	84 (49)	42 (9)	19 (4)					6 (1)		7 (1)		95 (44)
Heptageniidae	20 (12)	69 (14)	34 (7)	47 (11)	43 (13)	69 (16)	36 (4)	39 (7)	32 (5)	22 (4)	19 (19)	6 (3)
Nematoda				1 (0)								
Total	169 (98)	474 (99)	425 (88)	395 (90)	193 (60)	270 (60)	682 (83)	269 (49)	390 (68)	253 (43)	94 (92)	209 (97)

TABLE 17. NUMBERS OF MISC. BENTHOS FROM STATION 6 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Coleoptera												
Elmidae					1(1)	1(1)	1(0)					
Diptera												
Tipulidae	5(8)	1(1)	2(2)	2(2)			1(0)		1(1)	1(0)	3(4)	
Simuliidae		4(4)			3(2)	2(2)	1(0)			6(3)		
Tendipedidae		7(8)	7(6)	9(8)	5(4)	4(4)	21(10)			23(10)	35(51)	6(8)
Rhagionidae		4(4)			2(1)		2(1)		1(1)			
Tricliptera												
Hydropsychidae	2(3)		8(7)	4(4)	1(1)	1(1)	6(3)		13(7)	8(4)		2(3)
Rhyacophilidae		1(1)	6(5)	2(2)	6(4)	5(5)	4(2)		2(1)	4(2)	1(1)	2(3)
Brachycentridae				1(1)	1(1)		2(1)		1(1)	1(0)		
Limnephilidae	2(3)	2(2)	6(5)	7(7)	3(2)	4(4)			2(1)		1(1)	1(1)
Ephemeroptera												
Ephemeridae	6(9)	19(22)	29(25)	18(17)	32(22)	22(20)	13(6)		27(15)	31(14)	9(13)	13(17)
Baetidae	22(33)	9(10)	8(7)				11(5)		7(4)	16(7)	2(3)	20(26)
Heptageniidae	27(41)	24(27)	36(31)	43(41)	37(26)	29(27)	17(8)		42(24)	42(19)	11(16)	19(25)
Nematoda					1(1)							1(1)
Total	64	71	102	86	92	68	79		96	132	62	64
Individuals	(97)	(81)	(87)	(81)	(64)	(63)	(36)		(54)	(58)	(90)	(84)

TABLE 18. NUMBERS OF MISC. BENTHOS FROM STATION 7 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Turbellaria				1(1)						1(0)		
Coleoptera												
Elmidae			5(3)	6(4)	11(7)	4(1)	7(1)		3(1)	2(1)		
Diptera												
Tipulidae	1(1)	4(2)	1(0)	3(2)		4(1)			3(1)	2(1)		1(2)
Simuliidae	1(1)	5(3)	4(2)	5(4)		8(3)			8(3)	6(2)	1(2)	2(4)
Tendipedidae	6(8)	43(27)	14(7)		22(14)	133(46)	12(2)		10(3)	8(3)	1(2)	
Rhagionidae									2(1)			
Tricriptera												
Hydropsychidae			4(2)	6(4)	3(2)				3(1)	2(1)		
Rhyacophilidae	6(8)	3(2)	16(8)	15(10)	17(11)	13(4)	132(25)		37(12)	56(22)	2(3)	2(4)
Limnephilidae		3(2)	17(9)	12(8)	4(2)	2(1)				6(2)		
Ephemeroptera								ICE				
Ephemeridae	8(10)	25(16)	34(18)	34(24)	31(19)	11(4)	38(7)		23(7)	12(5)	7(12)	8(18)
Baetidae	42(54)	32(20)	17(9)			31(11)	52(10)		97(30)	67(26)	20(34)	20(45)
Heptageniidae	12(15)	32(20)	23(12)	41(28)	21(13)	12(4)	24(5)		19(6)	17(6)	22(37)	8(18)
Nematoda		1(1)										
Total	76	148	135	123	109	218	265		205	179	53	41
Individuals	(97)	(94)	(72)	(85)	(68)	(75)	(51)		(64)	(69)	(90)	(93)

TABLE 19. NUMBERS OF MISC. BENTHOS FROM STATION 8 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Hydracarina					2(2)							
Coleoptera			1(1)									
Elmidae												
Diptera												
Tipulidae	1(2)	2(4)		2(2)	2(2)				2(1)	2(1)		
Simuliidae		2(4)	3(2)								7(7)	
Tendipedidae		5(9)	2(2)	2(2)	9(7)					12(9)	4(4)	
Rhagionidae									4(1)	2(1)		
Tricoptera												
Hydropsychidae				1(1)	4(3)				2(1)		1(1)	
Rhyacophilidae	2(3)	1(2)	51(39)	11(9)	9(7)				43(14)	14(10)	6(6)	9(11)
Limnephilidae	12(20)	3(6)	4(3)	8(6)	3(2)				12(4)	13(10)	4(4)	1(1)
Ephemeroptera												
Ephemeridae	10(16)	6(11)	36(28)	32(26)	15(12)				32(11)	33(24)	6(6)	16(20)
Baetidae	7(12)	12(23)	10(8)		5(4)				92(31)	12(9)	45(47)	35(44)
Heptageniidae	20(33)	16(30)	15(12)	44(35)	18(15)				14(5)	4(3)	6(6)	19(24)
Nematoda				2(2)								
Total	52	47	122	102	67				201	92	79	80
Individuals	(85)	(89)	(94)	(82)	(54)				(67)	(66)	(83)	(100)

TABLE 20. NUMBERS OF MISC. BENTHOS FROM STATION 9 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Turbellaria	6(4)	18(9)	19(9)	18(6)	26(9)	4(1)		24(8)	54(34)	14(10)		
Hydracarina			1(0)									
Coleoptera												
Elmidae			1(0)		2(1)	2(1)						
Diptera												
Blepharoceridae	1(1)				1(0)							
Tipulidae			2(1)						2(1)	1(1)		1(3)
Simuliidae			2(1)						4(1)	10(6)	15(10)	
Tendipedidae	1(1)	3(2)		5(2)	24(8)	4(1)					10(7)	
Rhagionidae												
Tricoptera												
Hydropsychidae	1(1)	1(1)	10(5)		4(1)	2(1)	5(2)		4(1)	7(4)	1(1)	
Rhyacophilidae	8(8)	43(29)	13(7)	24(11)	50(16)	51(17)	95(33)		80(27)	15(10)	32(22)	3(8)
Brachycentridae					2(1)							
Limnephilidae		5(2)	3(1)	6(2)	1(0)	4(1)			3(1)	3(2)	7(5)	
Ephemeroptera												
Ephemeridae	14(15)	24(16)	28(14)	2(1)	7(2)	5(2)	25(9)		8(3)	5(3)	17(12)	3(8)
Baetidae	25(26)		12(6)		1(0)	2(1)			6(2)		16(11)	
Heptageniidae	44(46)	42(29)	44(22)	39(18)	36(11)	37(12)	16(6)		37(13)	12(8)	10(7)	27(71)
Nematoda				1(0)	2(1)	2(1)	1(0)					
Total	94	119	130	99	126	153	156		168	108	123	34
Individuals	(99)	(81)	(66)	(46)	(39)	(51)	(54)		(57)	(69)	(86)	(90)

TABLE 21. NUMBERS OF MISC. BENTHOS FROM STATION 10 (NUMBERS IN PARENTHESES INDICATE NEAREST WHOLE PERCENTAGE OF TOTAL BENTHOS).

	July	A	S	O	N	D	J	F	M	A	M	June
Turbellaria			1(1)									
Coleoptera												
Elmidae		1(1)	1(1)	1(0)	1(0)							1(1)
Diptera												
Tipulidae		2(2)		2(1)	2(1)					3(1)	2(3)	
Simuliidae		2(2)	2(1)		2(1)							
Tendipedidae		1(1)		6(2)	10(3)					1(0)	2(3)	2(2)
Rhagionidae											5(7)	
Tricoptera												
Hydropsychidae	1(1)		1(1)	1(0)						2(1)	3(1)	2(2)
Rhyacophilidae	14(18)	3(2)	72(43)	64(22)	76(22)					152(68)	91(40)	12(9)
Limnephilidae	19(24)	14(11)	8(5)	9(3)	6(2)					3(1)	22(10)	11(8)
Ephemeroptera												
Ephemeridae	11(14)	15(12)	10(6)	12(4)	9(2)					16(7)	5(7)	11(8)
Baetidae	18(23)	13(10)	5(3)	7(2)	34(10)					9(4)	44(19)	70(53)
Heptageniidae	13(16)	62(50)	42(25)	41(14)	93(26)					23(10)	21(9)	17(13)
Nematoda				1(0)								
Total	76	113	142	144	233				205	185	64	126
Individuals	(96)	(91)	(84)	(50)	(66)				(91)	(81)	(890)	(95)